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**Continued Enhancement of California Earthquake Clearinghouse Operations
through Improved Data Collection, Sharing, and Training:
Collaborative Research with California Geological Survey (CGS) and Earthquake
Engineering Research Institute (EERI)**

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Abstract

This report describes progress on the five tasks proposed under the NEHRP grant. During this grant period the Clearinghouse continued building on technology advances to improve how it can share and use data. Activities included two exercises, a training workshop, and an activation of the Clearinghouse following the August 24, 2014 South Napa Earthquake. Each of these events provided opportunities for participating organizations to use various data collection and visualization tools and to understand the types of data that each agency will be contributing to the Clearinghouse. Significant outreach was also undertaken to familiarize agencies with the options for contributing data, as well as for using data submitted by the scientific and engineering communities. Additionally, enhancements to the California Clearinghouse website and the virtual clearinghouse website template were implemented. Finally, the South Napa Earthquake provided an important opportunity for the Clearinghouse to test procedures and data collection methods after a real earthquake which led to many rapid updates in the weeks after the earthquake and helped identify areas for improvement.

Background

After a damaging earthquake in California, the California Earthquake Clearinghouse will be the contact point for researchers, scientists, and practitioners conducting reconnaissance. The Clearinghouse will facilitate the coordination of post-earthquake field investigations and help to share observations and knowledge among the community. Established in 1972, the Clearinghouse has activated a physical location more than ten times. The last major clearinghouse activation was after the South Napa Earthquake in August, 2014.

The Clearinghouse is managed by representatives from five core groups: the California Geological Survey (CGS), the U.S. Geological Survey (USGS), the Earthquake Engineering Research Institute (EERI), the California Office of Emergency Services (CalOES) and the California Seismic Safety Commission. This final report summarizes activities of two of the managing partner organizations of the Clearinghouse—the California Geological Survey and the Earthquake Engineering Research Institute—under a grant to improve data collection, management and dissemination.

There were 5 major tasks proposed under this grant:

1. California Natural Resources Agency (CNRA) implementation of XchangeCore (formerly UICDS) to support California Earthquake Clearinghouse
2. Improve the integration of data provided by various agencies as well as created by a small suite of field tools
3. Develop a training program on the use of the virtual clearinghouse and the various field tools
4. Initiate discussions with the various organizations that will want to extract data from the Clearinghouse core, and identify options for archiving such data

5. Enhance the Clearinghouse website to make it a more effective portal for mitigation and preparedness information, earthquake hazard resources and post-earthquake information

The following sections report on progress under each of these tasks.

1. California Natural Resources Agency (CNRA) implementation of XchangeCore (formerly UICDS) to support California Earthquake Clearinghouse (Lead: CGS, Unfunded Task)

FEMA-NEHRP- USGS Circular 1242: The Plan to Coordinate NEHRP Post-Earthquake Investigations (<http://pubs.usgs.gov/circ/1242/pdf/c1242.pdf>), describes the requirement to share relevant scientific and technical assessments with emergency managers; (p.15) Section 5.3, Recommendation 3 – Formalize Data Management and Archiving, Potential Solution – *Research on cost-effective field data collection* “...the development and free dissemination of standardized software applications and associated data protocols for use both in the field and for downloading data.” However, there is no clear direction as to how this mandate shall be achieved.

The goal of the Clearinghouse Technology Interoperability project is to facilitate secure, two-way sharing of information, both geospatial and non-geospatial, between the tools and technologies used by the organizations responding to an earthquake in California. In addition, we are working to orchestrate data into meaningful, incident related content, in standardized formats, for use by decision-makers. The technology we are using to facilitate information exchange is XchangeCore, developed through the U.S. Department of Homeland Security. Over the last three years, the Clearinghouse has demonstrated Clearinghouse information and products are able to be delivered to, and displayed in, a number of different applications, including Google Earth, ArcGIS Online (AGOL), Web EOC, and our Clearinghouse SpotOnResponse tool.

California Earthquake Clearinghouse

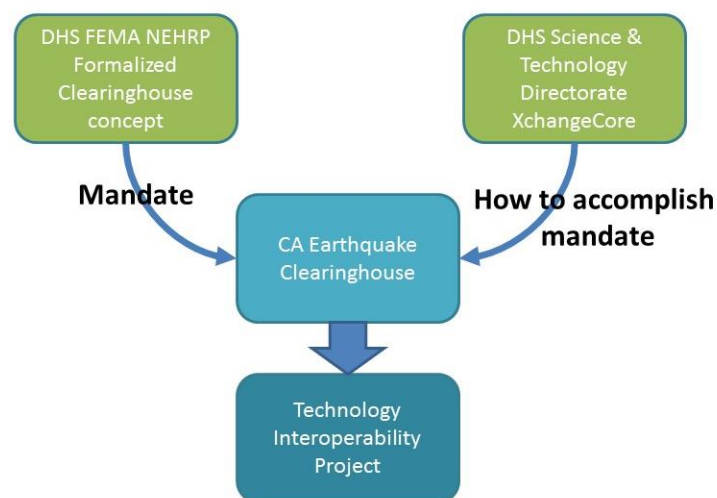


Figure 1: Clearinghouse Technology Relationships

In brief, XchangeCore allows agencies to share data that can come in different formats without going through a cumbersome conversion process. Large data sets that are maintained by Caltrans, for example, can be shared directly and automatically with the California Office of Emergency Services, and vice versa, directly through this technology, without converting databases into a common software. XchangeCore also allows agencies to specify levels of sharing—so, for example, the state Department of Public Health can control what state agencies can have access to various levels of their data.

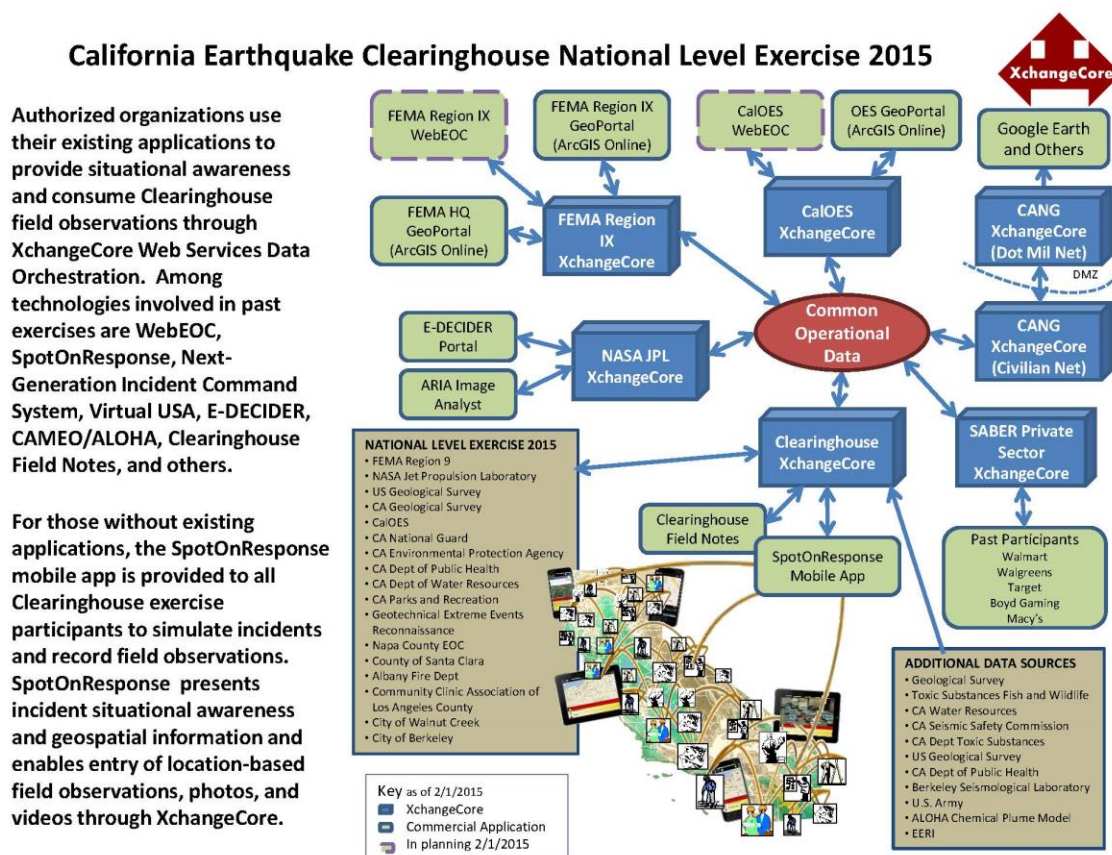


Figure 2: Clearinghouse Technology Relationships

Particular strengths of the XchangeCore system include the facts that it is a large, robust, well-developed system, and that data are shared securely and immediately, among agencies and organizations with XchangeCore or an application connected to a XchangeCore. Clearinghouse partners represent a broad spectrum of organizations that participate in and support post-earthquake activities. Many of these individual Clearinghouse partner organizations are developing custom work flows leveraging the tools and technologies used by their organization. The XchangeCore technology offers a flexible architecture that supports the technologies (geospatial and non-geospatial) and custom workflows of scientific, engineering and emergency response organizations.

The Clearinghouse, using its XchangeCore, can draw information from agencies and organizations that can be used to direct Clearinghouse researchers in the field. And reciprocally,

emergency management agencies can access data from the Clearinghouse core in a faster, more automated manner. Data in the Clearinghouse core can be used to populate a virtual clearinghouse website. Data coming from the mobile XchangeCore device, SpotOnResponse, as well as some of the other mobile tools now being used by Clearinghouse partners, can be used to track all field investigators.

The Clearinghouse closely coordinated XchangeCore implementation efforts with Cal OES. Between 2011 and 2013, Cal OES was responsible for the larger umbrella RIMS re-build. During this grant period Cal OES hosted a pilot XchangeCore for the Clearinghouse, and other agencies and organizations shared their data through this core. In addition, Cal OES provided funding to develop an XchangeCore connector for Arc GIS Online, and, XchangeCore connections into the Cal EOC boards for shelters, mission resources, schools and points of distribution. The Clearinghouse leveraged the fact that the spring state-level preparedness exercises between 2011 and 2014 were earthquake themed, and that in the fall there is the annual earthquake awareness event, the Great California ShakeOut. The Clearinghouse treated these annual events as opportunities to test and learn by conducting two exercises with support from the NEHRP funding in this grant.

Cascadia Exercise

Building on the previous four exercises held in 2012 and 2013, the fifth preparedness exercise took place on May 14, 2014 with the Clearinghouse as an official participant in the state-level exercise. The state-identified scenario was a M9 Cascadia earthquake and tsunami. This allowed for more sophisticated data collection and the sharing of scenarios during the exercise. Simulated reports of damage provided by participating counties provided points of interest for Clearinghouse participants who then submitted simulated observations about these points.

During the 2014 Cascadia Exercise, the Clearinghouse tested activation procedures and participating volunteers tested tools and technologies to collect and share, in real-time, scientific and engineering data, and to provide essential elements of information and situational awareness for decision support. Testing activation procedures and the simulated collection and uploading of data helps the Clearinghouse and its partner organizations develop and refine the concept of expanded operations and XchangeCore.

In addition to the Clearinghouse managing partner organizations, partners in this effort included the California National Guard, FEMA Region IX, NASA JPL, Cascadia Geoscience, as well as local jurisdictions including City of Walnut Creek. For the 2014 Cascadia Exercise, Cal OES established an XchangeCore pilot and as their contribution as a founding and managing Clearinghouse partner, made the core available for Clearinghouse partners. The Clearinghouse and partners used XchangeCore to share geo-spatial and non-geospatial information, in real-time, using (but not limited to) the following applications: WebEOC, Google Earth, ArcGIS Online, Next Generation Incident Command System (NICS), SpotOnResponse mobile data collection tool, Firefox, Chrome, and Internet Explorer. Approximately 300 incidents were generated and transported through XchangeCore, with 89 unique end-users. More than 306

separate field observations were submitted through applications connected through XchangeCore; 253 included updates of which 173 contained narrative, photos, videos, documents and even voice narration.

USGS Interoperability Assessment, June 2014

In June of 2014, The Clearinghouse participated in a USGS Interoperability Assessment, conducted in partnership with the Open Geospatial Consortium. The California Earthquake Clearinghouse gave a presentation on the Clearinghouse Technology Interoperability efforts. The USGS produced a 10-minute long summary video in which the Clearinghouse efforts with XchangeCore to improve information sharing capability is highlighted (video link: <https://www.dropbox.com/s/9lm0fvp0v24q9tl/USGS%20OGC%20IA.mp4?dl=0>). In addition, the USGS also recommended our efforts with XchangeCore as an example for other organizations to follow.

2. Improve the integration of data provided by various agencies as well as created by a small suite of field tools (Joint Leads: CGS and EERI)

Based on continued testing of field tools, user experiences in 2014 Cascadia Exercise, and lessons learned from the South Napa Earthquake, the suite of data collection tools recommended by the Clearinghouse is currently as follows:

Tool	Capabilities	Data Export Formats
Clearinghouse Field Notes	Web application that collects geo-tagged form data in the following areas: Fault Rupture, Liquefaction, Landslide, Tsunami, Lifelines, Buildings. Ability to associate a photo with each completed form.	GeoJSON, KML (aggregated data points)
EERI Batch Photo Upload Tool	Allows for batch uploading geotagged photos and pdfs using a downloadable java application. Also collects basic photo metadata including photographer and caption, as well as categorizing the images and noting the damage severity. (Categories include: Structural, Geotechnical, Transportation, Social Impacts, Nonstructural, Tsunami and Strong Motion Sensors)	KML, CSV (aggregated data points)
EERI Interactive Photo Upload Map	Allows for upload of up to four photos at a single point using an online interactive map interface. Also collects basic photo metadata including photographer and caption, as well as categorizing the images and noting the damage severity. (Categories include: Structural, Geotechnical, Transportation, Social Impacts, Nonstructural, Tsunami and Strong Motion Sensors)	KML, CSV (aggregated data points)
FieldNotes LT & Pro	Notetaking app for Android and iOS devices. Collects geotagged notes, photos, videos, and sketches. Has fully functional offline capability.	PDF, .txt + .jpg, KMZ (single user data points)
SpotOnResponse	Situational Awareness web application with a focus on emergency management. Allows for the creation of incidents and then enables users to provide text-based updates and attach relevant files (KML, pdf, photo, etc.) to those incidents.	GeoRSS Feed (aggregated data points)

While each of the tools in the list brings an important data collection feature into the suite, no single tool has the capability to systematically aggregate data from multiple sources while still visualizing the data in an easy-to-interpret, user-friendly way. As a result, the Clearinghouse needed a separate application to achieve data integration and visualization. Discussions with FEMA GIS specialists during the 2013 Clearinghouse ShakeOut Exercise led to the identification of ArcGIS Online as a powerful, robust, easy to use data visualization and aggregation tool. FEMA's use of ArcGIS Online after the 2013 tornadoes in Moore, Oklahoma, served as an example of how the Clearinghouse could use ArcGIS Online to aggregate and publish post-earthquake data.

In spring of 2014 an ArcGIS Online account was established for the Clearinghouse with a goal of testing and demonstrating the system's capabilities in the 2014 Cascadia Exercise. Ahead of the exercise, EERI organized members to stage data for the exercise using the suite of field tools. Then, during the exercise, a group of engineers met at the EERI office to collect data in real-time using the different field tools in the suite. Both staged and real-time data were aggregated into an ArcGIS Online Map. This map, as well as a summary of EERI team observations, were presented during the Clearinghouse exercise webinar. In addition to data collected by the "EERI team," data shared through the CalOES XchangeCore (formerly UICDS) was also imported into the ArcGIS Online map. A screenshot of the ArcGIS Online map is shown below.

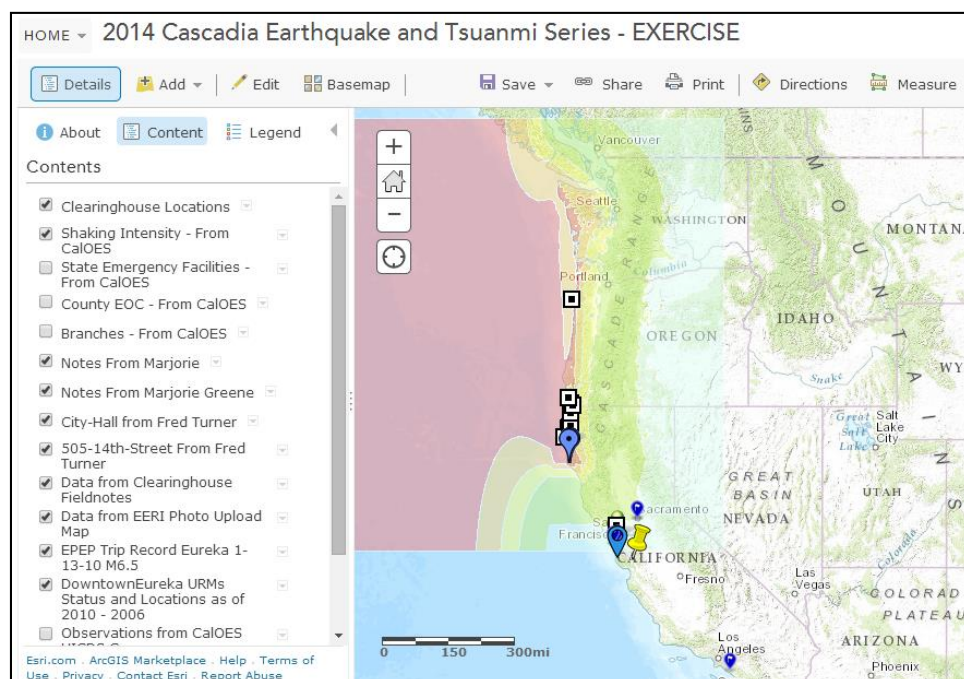


Figure 3: 2014 Cascadia Earthquake and Tsunami Series Exercise ArcGIS Online Map

The demonstration of ArcGIS Online during the exercise was quite successful and the data aggregation was manageable in real time. It became clear that the use of ArcGIS Online would help the Clearinghouse solve the data aggregation and visualization problem.

With the experience of the Cascadia Exercise, the Clearinghouse was in a position to mobilize a similar data aggregation map using ArcGIS Online following the South Napa Earthquake. Within hours of the earthquake, the ArcGIS Online map was created and publicly visible online. In the days following the earthquake the map contained over 3000 points from 30+ different data sources. Additionally, the map was viewed over 3500 times in the first month after the earthquake. A screenshot of the South Napa Earthquake ArcGIS Online map is shown below.

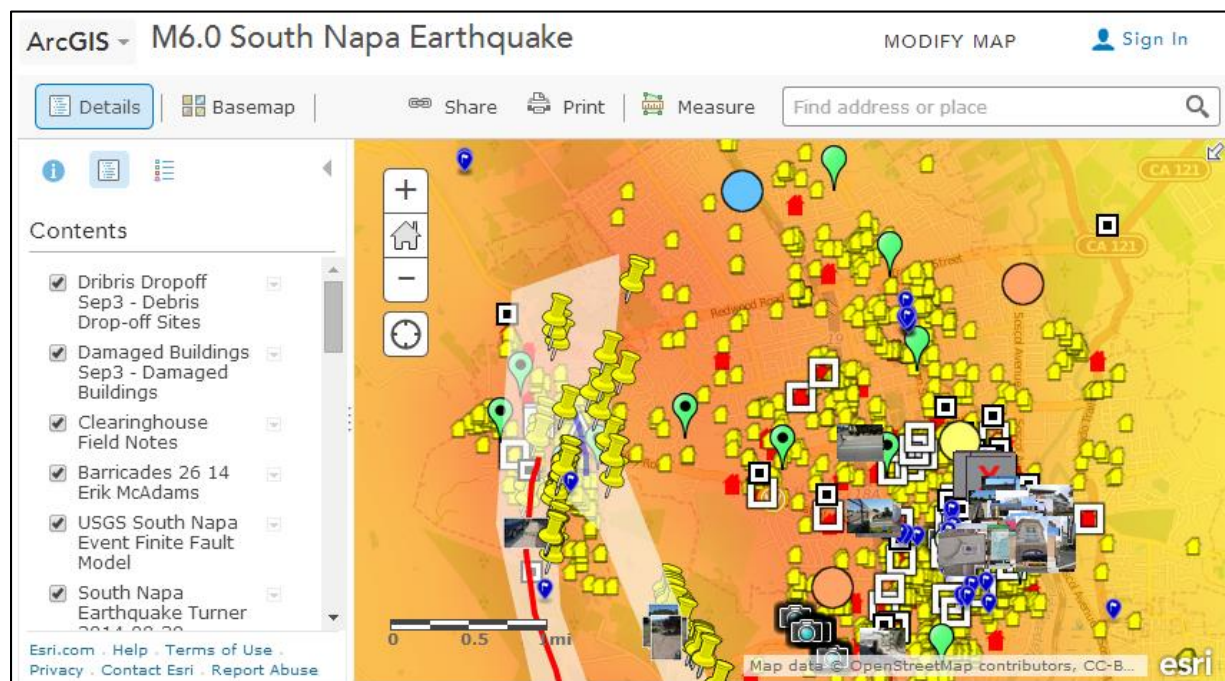


Figure 4: 2014 South Napa Earthquake ArcGIS Online Map

Continued efforts will be supported by FEMA to improve the visualization of the South Napa Earthquake data and to migrate the data to the FEMA GeoPlatform for long-term archiving.

3. Develop a training program on the use of the virtual clearinghouse and the various field tools (Joint Leads: CGS and EERI)

In April 2014, the Clearinghouse organized a workshop in Oakland, CA with CalOES, the City of Walnut Creek, the City of Berkeley, the CA National Guard, the National Association of Public Safety GIS Foundation, FEMA Region 9, the U. S. Department of Homeland Security, the NASA Jet Propulsion Laboratory, and the Northern California Regional Intelligence Center. All participants play a role, and have an interest, in post-earthquake data collection and management, as well as emergency response. Approximately 160 people participated, either in person or via the web. There was no cost to attend.

The workshop fostered discussion on how first responder agencies use and share spatial incident response data with other local agencies and with regional, state and federal agencies in California. The focus of the workshop was how to share data and to make maps for information in my agency and for decision support.

During the workshop, software applications (both desktop and mobile) and procedures to share incident response related data in a secure environment, already developed as a result of several federal DHS initiatives and state efforts, were demonstrated. The use of these tools, data, and procedures were successfully demonstrated during recent California Earthquake Clearinghouse exercises held in 2012 and 2013.

The workshop shared results from exercises and presenters demonstrated the use of various state and federally-developed emergency response tools, data and resources, designed to advance regional ability to prepare for, and respond to, an eventual major natural disaster or event. Participants learned how to input their own incident information, as well as how to access and combine these compilations of information with their own spatial systems and data. Participants in the workshop were able to test and apply improved skills in the Clearinghouse component of the 2014 Cascadia exercise.

In addition to trainings focused on first responders, resources for individuals and teams conducting reconnaissance were also developed. Training resources and methods were trialed with a group of EERI members planning to participate in the 2014 Cascadia Exercise. Detailed user notes for the suite of field tools were prepared and then updated based on comments from the group and then updated again to reflect changes made to the tools after the South Napa Earthquake. The development and trial of training materials is laying the groundwork for a comprehensive Clearinghouse training program that clearly articulates how individuals and groups can participate and what steps they can take to share and view data.

4. Initiate discussions with the various organizations that want to extract data from the Clearinghouse core, and identify options for archiving such data (Lead EERI)

The South Napa Earthquake was an excellent opportunity to work with different organizations to view and share data. The use of ArcGIS Online to host data made it possible for other organizations to view or download any data shared with the Clearinghouse. All data aggregated by the Clearinghouse is currently being migrated to the FEMA GeoPlatform, which will maintain public access and provide stable, long-term archiving. Discussions are also underway to implement restricted areas where sensitive data can be stored and accessed by approved groups or individuals.

Following ShakeOut 2014, the Clearinghouse organized two full-day workshops held in Los Alamitos on October 21 & 22, 2014. The first workshop focused on overflight coordination with a goal of understanding the Mission Tasking process and defining Clearinghouse needs and requirements in order to be able to draft pre-scripted Mission Tasks for various Areas of Interest (AOI) before the next large earthquake on the southern San Andreas Fault system. The

Clearinghouse has also been working with the branch of CA OES that will manage overflights after an earthquake. This new OES Air Operations Branch is working with the Clearinghouse to identify the types of data that could be collected in an overflight and the equipment necessary to gather and share such data. Discussion during the workshop benefitted greatly from successful overflight coordination during the South Napa Earthquake.

The second workshop, on information collection, focused on concepts related to the fast and planned orchestration of data into easily distributed and understood products containing Essential Elements of Information that support decision making. For example, the need for post-earthquake information, how it is collected by various organizations, and how information can be organized to make it easy for other organizations to find, access, and most importantly, to use. Clearinghouse partners, as well as partners from FEMA Region 9, CAL OES, California National Guard, and the southern California earthquake community and local response organizations, provided briefings on their information requirements and capabilities. Different ways to analyze data and create decision support products that will be useful to various organizations were discussed in order to help participating organizations think about products and concepts that could be integrated into plans for the State Capstone/National Level Exercise in May 2015.

5. Enhance the clearinghouse website to make it a more effective portal for mitigation and preparedness information, earthquake hazard resources and post-earthquake information (Lead: EERI)

EERI continues to maintain the California Clearinghouse website and publish new content. As manager of the California Clearinghouse website, the South Napa earthquake proved that EERI staff cannot manage simultaneously updating both the California Clearinghouse website and an earthquake-specific Virtual Clearinghouse website. Therefore, as EERI has already developed a Virtual Clearinghouse website template, visitors to the California Clearinghouse website would be directed to an earthquake-specific virtual clearinghouse website. This website would be the only site updated regularly and would contain all updates from the California Clearinghouse. Following this procedure, a virtual clearinghouse website was established for the South Napa Earthquake which continues to be updated with new information, data, and reports. Using the earthquake as a learning experience, improvements were made to the virtual clearinghouse template, including adding a “Teams” section to track participation in the Clearinghouse and improved instructions, including videos, for how to contribute information to the Clearinghouse. A screenshot of the homepage of the South Napa Earthquake Virtual Clearinghouse website, which was live within 12 hours of the earthquake and had 1500 visits in the first four days after the earthquake, is shown on the next page.

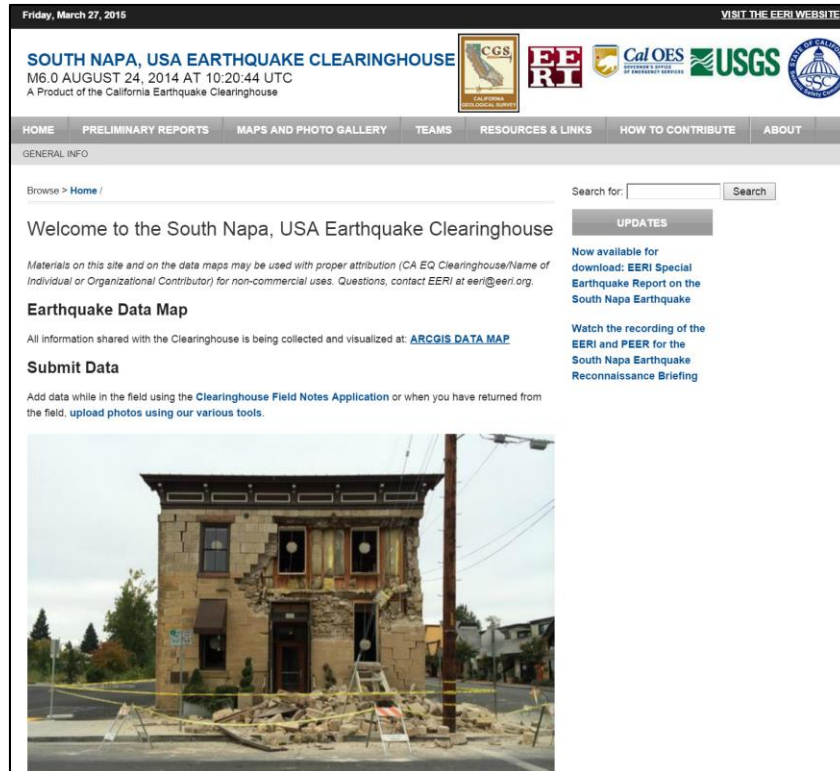


Figure 4: 2014 South Napa Earthquake ArcGIS Online Map

Conclusions

The USGS grant has allowed CGS and EERI to make major advances to the virtual clearinghouse concept, including the testing of various field tools and data viewing and management protocols. CGS and EERI activities led to improved visibility of the Clearinghouse and increased coordination with a wide range of agencies and organizations in the state. This increased visibility and coordination continue to grow at a rapid rate. Participating in the continuing series of exercises has brought in new partner organizations and individual participants. Organizations and agencies from other states have also started following the Clearinghouse in order to develop their own Clearinghouse protocols. A well thought out concept of operations for the physical and virtual clearinghouses will ensure that the community will capture important scientific and engineering data after the next California earthquake and play a role in the response and recovery process through automated information sharing with the California Office of Emergency Services. Much of the progress made during the grant period was informed by experiences after the South Napa Earthquake and this report provides a summaries of activities relevant to the grant. A full discussion of the Clearinghouse activation for the South Napa Earthquake will be available on the Clearinghouse website.